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(54) Combined degassing and flotation tank

(57) A combined degassing and flotation tank for separation of a water influent containing considerable amounts of oil and gas. A rotational flow is created in the tank which forces the lighter components such as oil and gas droplets towards a first baffle (5) from where they coalesce and rise to the surface of the liquid and are removed via the outlet (3) whereas the heavier parts are forced down where the heavy particles sink to the lower part where they may be removed as a sludge and the water is forced up between said first baffle (5) and an inner baffle (6) and leaves the tank via a central bottom outlet (4). A screen (7) may be provided centrally or as a separate unit to remove fine particles from the effluent.

The combined degassing and flotation tank is particular suited for use in oil production at sea for removal of oil and gasses from water streams before the water is returned to the sea.

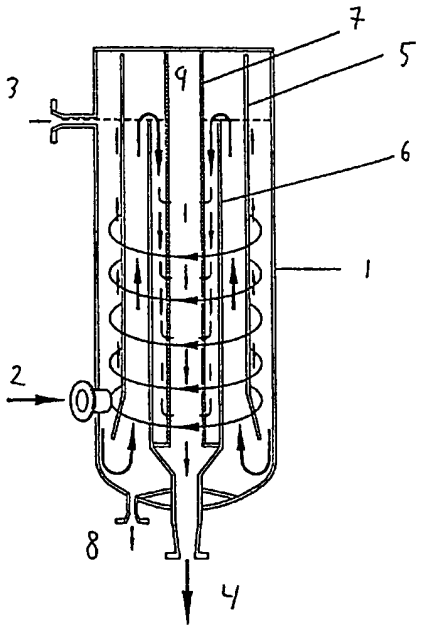

Figure 2.

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Description

Field of the invention

[0001] The present invention relates to a combined degassing and flotation tank which is particular suited for use in separation processes where a water phase containing oil and gas is separated into these constituents.

[0002] The invention is applicable within a broad range of industries comprising the petroleum industry, including oil exploration and production, refining, transport, storage, cleaning of tanks and/or equipment etc.

Background for the invention

[0003] In the oil industry the production of crude oil involves pumping a mixture of oil, gas and water from subterranean reservoirs. At the well-head a initial separation usually takes place, and the crude oil still containing some gas and water is treated in one or more separators to remove more water and gas before the crude oil is ready for refining.

[0004] At offshore oil production the water phase coming from the separation at the well-head or subsequent separators is usually discharged into the sea after a cleansing that involves the partial removal of gas, oil, chemicals and other impurities. Today this cleansing is accomplished using large equipment such as oil/gas separators, flotation tanks, hydro cyclones and degassing tanks occupying a substantial space at the production platforms.

[0005] With ageing of the oil fields one often finds that the volume of water accompanying the oil becomes much larger and consequently the capacity for water treatment often needs to be increased to treat the increasing amounts of water.

[0006] Further, there is a general concern of the pollution caused by oil production at sea, particular when the oil production takes place in areas that are considered as environmentally fragile, such as arctic areas or fishing areas. In the oil industry there is a fear that a demand for a significant lower limit for the outlet of oil would turn the oil production from a number of the known reservoirs uneconomical if one has to rely on the equipment used at present. Thus great efforts have been made by industry and authorities to find ways to reduce the outlet of oil during oil production at affordable prices.

[0007] On oil production platforms intended for operation at sea very limited space is usually available. Therefore there are very strict constraints on the space available for installation of new equipment that may be needed in order to handle increasing amounts of water, in particular if one should honour the rising concerns for the environment and reduce the pollution. An even stricter constraint on space may be encountered if one considers the establishment of an oil production at the sea bed level.

[0008] In the prior art a number of oil-gas-water separators are known. In US 4,424,068 a separator and a method for separating a mixture of oil, gas and water, such as may be received from an oil-well is described. The separator is in the form of a vessel divided into separation chambers and provided with a number of baffles and a dynamic separator where the incoming mixture changes direction several times. Despite that the separator have been known for several years it seems not to have been widely used. Further as the separator comprises several chambers and many parts the maintenance will be time consuming which may lead to costly stop of oil production.

[0009] US 4,364,833 describes a separator comprising one sector containing numerous plates arranged horizontally and parallel in order to confer coalescence of small oil drops to larger oil drops, and a second sector containing numerous plates arranged vertically and parallel in order to let the formed larger oil drops rise to the top where they form an oil layer which is collected. As the separator contains a number of narrow passages between the parallel plates these passages are susceptible for clogging by solids contained in the incoming flow which may lead to stop for cleaning.

[0010] US 3,797,203 describes a separator containing a number of conically formed screens on the surface of which small oil droplets coalescence to larger oil drops which rise to the top of the separator where they can be collected as an oil phase.

[0011] WO 99/20873 describes a sand trap that may be placed on a oil well in order to remove heavier particles such as sand before further processing of the crude oil. The device has a mouth towards an relatively narrow part of a tank with a spatial connection towards a relatively widened part of the tank where sand and heavy particles precipitate.

[0012] Despite the number of known oil-gas-water separators there is still a need for an improved oil-gas-water separator with a better separation of the phases, which do not need large spaces, which can be continuous operated with low requirement for maintenance and which can be manufactured and operated at moderate price.

Brief description of the invention

[0013] It has now been found that these needs may be fulfilled by using a combined degassing and flotation tank comprising an essentially cylindrical vertical tank (1), a tangentially arranged inlet (2) placed in the lower part of the tank, an outlet (3) for gas and oil placed in the upper part of the tank, an outlet (4) for water placed essentially in the centre of the bottom, and at least one first essentially concentric arranged vertical baffle (5) extending from the top of the tank leaving a passage for water in the lower part of the tank, and at least one essentially concentric, cylindric vertical baffle 6) of smaller diameter than the at least one baffle (5) and extending

from the bottom of the tank leaving a passage in the top portion of the tank.

[0014] In a preferred embodiment the combined degassing and flotation tank further comprises an outlet (8) for sludge and particulate material placed in the lower part of the tank.

[0015] Thus one aspect of the invention is formed by said combined degassing and flotation tank.

[0016] It has turned out that the combined degassing and flotation tank according to the present invention can perform the desired separation of an oil/gas phase from a water phase with a surprisingly high efficiency. In use for water treatment in oil production remaining oil and gas can be removed from the outgoing water phase providing an effluent with a very low content of hydrocarbons simultaneously with the removal of sand and other particulate materials. Further, as the throughput of the tank is very high the space requirement is very modest in relation to the amount of treated water.

[0017] In a preferred embodiment the combined degassing and flotation tank comprises a screen for removal of very small particles such as e.g. asphaltenes. The screen may be arranged centrally in the tank or may be provided as a separate unit connected to the outlet of the tank.

[0018] In another preferred embodiment a filtration unit, such as an unit of the adsorption filter type, is connected to the outlet of the combined degassing and flotation tank, which embodiments leads to a very efficient and high removal of hydrocarbons from the water.

[0019] The combined degassing and flotation tank according to the invention is particular suited for treating the water phase originating from the well-head or from subsequent separators before said water phase is discharged to the sea at offshore oil production plants.

[0020] Thus, the use of the combined degassing and flotation tank in oil production forms another preferred aspect of the invention.

Brief description of the drawings

[0021]

Fig 1. is a schematic section through a combined degassing and flotation tank according to the invention,

Fig 2. is a schematic section through a combined degassing and flotation tank according to the invention provided with a centrally placed screen (7) and an outlet for sludge (8), showing the flow in the tank,

Fig 3. is a graph belonging to the experiment indicated in the example showing the efficiency of the combined degassing and flotation tank according to the invention.

Detailed description of the invention

[0022] In connection with the present invention the term "essentially cylindrical" means that the tank is substantially circular and the top and bottom of the tank is plane or curved. In use the tank is placed so that the axis of the cylinder is essentially vertical.

[0023] Referring to Fig 1. and 2., a tank (1) is provided with a inlet (2) placed in the lower part of the tank. The inlet (2) is arranged tangentially which causes the incoming water to rotate in the tank as illustrated in fig. 2. This rotation creates a centrifugal force which forces the lighter oil drops towards a baffle (5), where they coalesce forming larger drops that eventually rise and are gathered on the top of the liquid between the tank wall and the first baffle (5). Here the oil is removed via an outlet for oil and gas (3).

[0024] Simultaneously sand and other heavy particles that may be entrained by the inlet mixture are forced towards the wall of the tank(1) and fall to the bottom of the tank forming a sludge. The deposition of sludge and solid material in the lower part of the tank is disadvantageous as the separating capacity of the tank may be lowered.

[0025] Unless the water to be treated is substantially free for particulate material that may form a sludge an outlet (8) for sludge and particles are therefore preferably placed in the bottom of the tank for continuous or discontinuous removal of sludge.

[0026] The water is forced down under the first baffle (5) and up between said first baffle and the outlet (4) and/or the inner baffle (6). The water rises to a top level determined by the height of the inner baffle (6), and leaves the tank via the outlet (4).

[0027] The baffles are formed essentially as cylinders open in one end and the other end closed by the top or the bottom of the tank.

[0028] The first baffle (5) is extending from the top of the tank and may be placed forming a gap between said first baffle (5) and the top of the tank. The first baffle (5) may be formed having a uniform diameter along the total height of the baffle, or it may be formed having a larger diameter in the lower end in order to provide a maximal rotational speed of the liquid in the inlet zone.

[0029] The inner baffle (6) is extending from the bottom of the tank and is in one embodiment formed by an extension of the water outlet (4). In the combined degassing and flotation tank according to the invention the inner baffle (6) provides a function as an overflow for the tank determining the water level of the tank. The inner baffle (6) may be formed by the outlet pipe (4) extended to the desired water level.

[0030] It is preferred that the water level is predetermined to the same level as the outlet for oil and gas (3) in order to obtain a continuous removal of oil and gas from the tank avoiding accumulations which may lead to reduced capacity for separation.

[0031] Between the first baffle (5) and the inner baffle (6) may be inserted further baffles which preferably are arranged extending alternatively from the top and the bottom of the tank. Such baffles will force the water to

make extra travels up and down the tank which may allow more gas to escape from the water phase.

[0032] Each baffle are arranged substantially concentrically with the tank.

[0033] The tank is operated at low pressure in order to let the gas escape the water phase. By low pressure is meant a pressure below 10 bar, such as less than 5 bar or even at atmospheric pressure. By such a low pressure most of the gas will form bubbles in the zone around the inlet (inlet zone) and will as the oil drops be forced to the first baffle (5) where they rise to the top of the tank where the gas leaves via the outlet for oil and gas.

[0034] The formation and rise of gas bubbles in the inlet zone further mimics the effects created in traditional flotation tanks where the rise of bubbles of added air leads to an enhancement of the separation of oil from the mixture. Without wishing to be bound by the theory it is believed that bubble formation and subsequently rise of the formed bubbles in the inlet zone of the combined degassing and flotation tank according to the invention is contributing to the surprisingly high separation efficiency observed.

[0035] However, a small amount of gas may be brought below the first baffle (5) by the water, and released during the following up and down movement of the water phase. Gas released after the passage of baffle (5) will rise to the upper compartment (9) of the tank. In order to prevent pressure building in the upper compartment (9) the first baffle (5) may be designed to allow gas from the upper compartment (9) to escape via the outlet for oil and gas (3). Such a passage for gas could be provided by placing the top of the first baffle (5) in a short distance below the top of the tank leaving a passage for gas over the first baffle (5). Alternatively said first baffle (5) may be perforated in the upper end to allow passage of gas. If the tank is provided with further optional baffles extending from the top of the tank these should similarly be designed to allow passage of gas.

[0036] As a further alternative a vent may be provided in the top of the tank to prevent gas entrapment and pressurizing in the upper compartment.

[0037] The combined degassing and flotation tank may be provided with a screen to remove fine particles such as asphaltenes, from the effluent. The screen may be placed integrally in the tank as a central cylindrical screen (7) forming a tube around the outlet (4), it may be placed directly mounted to the outlet or as a separate unit outside the tank connected to the outlet.

[0038] In one embodiment the inner baffle (6) if formed by the screen (7), in which case the water level is determined by the flow rate through the screen (7).

[0039] The screen is made as conventional screens using known materials and designs for screens, as it will be known to the person skilled in the art.

[0040] In the case of a combined degassing and flotation tank equipped with a inner baffle (6) and a central cylindrical screen (7) the tank is conveniently provided with a outlet for removal of material retained by the screen (not shown in the figures) placed in the bottom next to the outlet (4) for the effluent.

[0041] The dimensions of the combined degassing and flotation tank may be selected depending on the amounts of water intended to be treated. In operation is has been found that the residence time in the tank for a liquid to be treated may be selected between 5 and 300 seconds, preferably 5 - 150 seconds, more preferred 10 - 60 seconds, even more preferred 10-40 seconds. A particular preferred residence time is about 20 seconds.

[0042] For the combined degassing and flotation tank according to the invention, an efficient flotation volume may be calculated as the volume of the space bounded be the tank (1), the inner baffle (6) and the height of the liquid in the tank. Based on the residence time the capacity of the tank may be calculated e.g. a tank with a efficient flotation volume of 1 m^3 and a residence time for the liquid of 20 seconds has a capacity of 180 m^3 per hour.

[0043] The ratio of height to diameter of the tank can be selected within wide limits preferably in the range of 1:1 to 4:1 more preferred from 1:1 to 2:1.

[0044] It is within the skills of the person skilled in the art to select materials used for the construction of the tank based on the actual conditions for the intended use, such as the amounts of liquid to be treated, the composition of said liquid, the selected pressure, the temperature of the liquid and the presence of possible corrosive chemicals in any of the phases of the mixture.

[0045] In the way the combined degassing and flotation tank is formed all surfaces are vertical or at least having a steep inclination with the exceptions of the surfaces in the sectors intended for collection of particulate material and sludge, which sectors also have outlets for removal of these materials. Further no narrow passages are present in the tank. Consequently there is no place in the combined degassing and flotation tank according to the invention which is susceptible to clogging by solid materials. Therefore the combined degassing and flotation tank may be operated continuously without or only with a minimal need for maintenance. The necessary maintenance such as replacement of a cylindrical screen if so provided can easily be performed from the top of the tank, which preferably is constructed to be removable. Thus the combined degassing and flotation tank according to the invention has a remarkable robustness i.e. it can be run for long periods without interruptions, and the few stops that may be required for maintenance can be made short.

[0046] The high capacity combined with the small occupied space and the robustness of the combined degassing and flotation tank according to the invention makes it particular suited for use at offshore oil plants such as oil production platforms. Further it is also well suited for use in oil production in plants located on the sea bed, because at such a location the constraints on space may be even strickter than on traditional oil pro-

duction platforms and the capacity for maintenance may be lower.

[0047] In use the combined degassing and flotation tank according to the invention routinely reduces the oil content of a oil/water mixture to 20 mg/l or less starting from several hundred mg/l e.g. 200-800 mg/l.

[0048] In a preferred embodiment the combined degassing and flotation tank is used in combination with a filtration unit, preferably of the adsorption/absorption type, which filtration unit may further reduce the oil content of the effluent water. A particular suited filtration unit for such a combination is the filtration unit disclosed in the European Patent application No. 00610080.4. Starting from an oil/gas/water mixture containing 400-800 mg hydrocarbons per litre, a reduction of hydrocarbon content to less than 20 mg/l after the combined degassing and flotation tank and a further reduction to 5 mg/l or less after the filtration unit can routinely be obtained, while the high throughput is maintained.

[0049] Even though the combined degassing and flotation tank has been described mainly with respect to uses in oil production the invention is not limited to such uses but can be used within a broad range of industries where separations of a liquid mixture of water, a liquid insoluble in water and a gas takes place.

[0050] Now the invention is described by an example which should not be regarded as limiting for the invention.

Example

[0051] A combined degassing and flotation tank corresponding to figure 2, having a diameter of 500 mm and a height of 1200 mm and an efficient flotation volume of 125 litre, was tested on water phase effluent from a second step oil separator from a commercial oil production platform. The sample water contained varying amounts of oil and gas in the range equivalent to approximately 50 - 200 mg hydrocarbon per litre. The intake varied between 1.8 and 9.5 m^3 /h.

[0052] The output water contained approximately 20 mg hydrocarbon per litre or less, during most of the experiments less than 20 mg/l. The efficiency of cleaning calculated as percentage hydrocarbon removed was during most of the experiment between 80 and 90 %.

[0053] The actual data is shown in fig. 3, which is a graph showing the concentrations of hydrocarbons in the inlet and the effluent stream of the combined degassing and flotation tank measured at regular intervals during the experiment.

Claims

1. Combined degassing and flotation tank comprising an essentially cylindrical vertical tank (1), a tangentially arranged inlet (2) placed in the lower part of the tank, an outlet (3) for gas and oil placed in the upper part of the tank, an outlet (4) for water placed essentially in the centre of the bottom, and at least one essentially concentric arranged vertical first baffle (5) extending from the top of the tank leaving a passage for water in the lower part of the tank, and at least one essentially concentric, cylindric vertical baffle 6) of smaller diameter than the at least one baffle (5) and extending from the bottom of the tank leaving a passage in the top portion of the tank.

2. Combined degassing and flotation tank according to claim 1, further comprising an outlet (8) for sludge in the lower part of the tank.

3. Combined degassing and flotation tank according to claim 1 or 2, where the lower part of the first baffle (5) has a larger diameter than the upper part of said first baffle(5).

4. Combined degassing and flotation tank according to any of the claims 1-3, where the inner baffle (6) forms an extension of the outlet (4) for water.

5. Combined degassing and flotation tank according to any of the claims 1-4, where the part of said first baffle (5) above the water level of the tank is formed to allow passage of gas.

6. Combined degassing and flotation tank according to any of the claims 1-5, further comprising a screen (7) for retaining particulate material.

7. Combined degassing and flotation tank according to claim 6, where the screen is arranged as a vertical cylindrical screen (7) in the centre of the tank.

8. Combined degassing and flotation tank according to claim 7, where the inner baffle (6) is formed by the screen (7).

9. Combined degassing and flotation tank according to claim 7, further comprising an outlet for solid material retained by the screen (7).

10. Use of a combined degassing tank according to any of the preceding claims, in oil production at sea level or at sea bed level.

11. Use of a combined degassing and flotation tank according to claims 10, in combination with a filtration unit connected to the outlet (4) for water of said tank.

12. Use of a combined degassing and flotation tank according to claim 10 or 11, for treating water from which the main portion of oil and gas has been removed previously by conventional means.

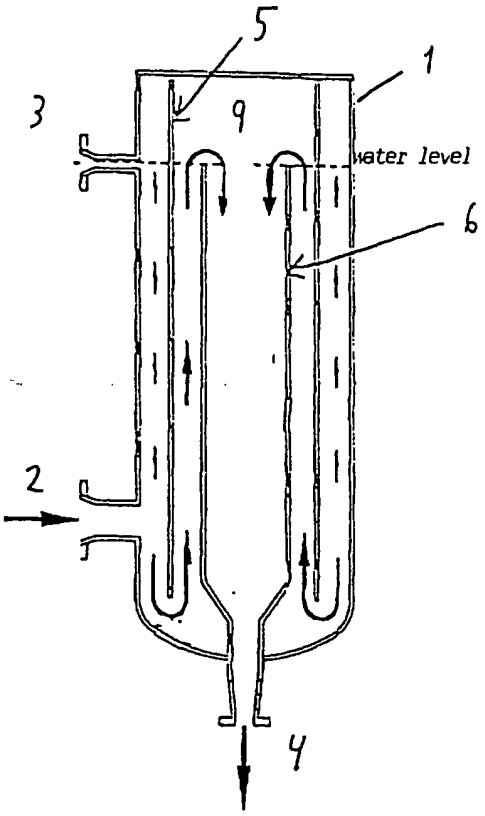


Figure 1.

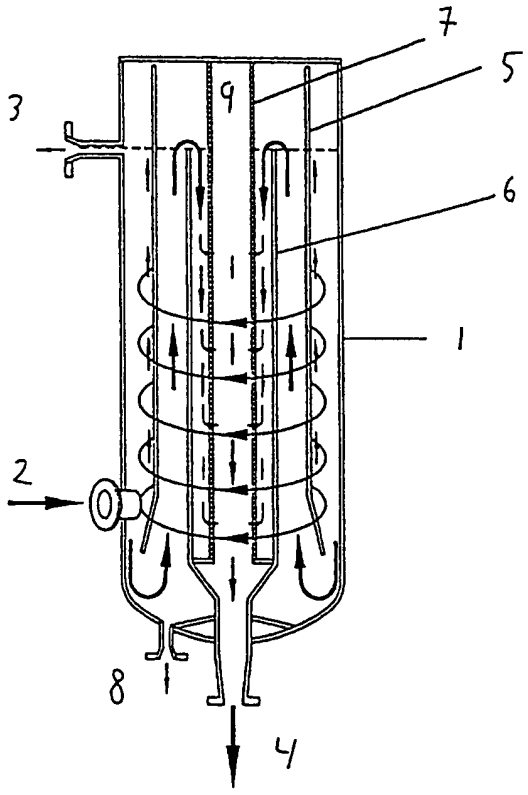
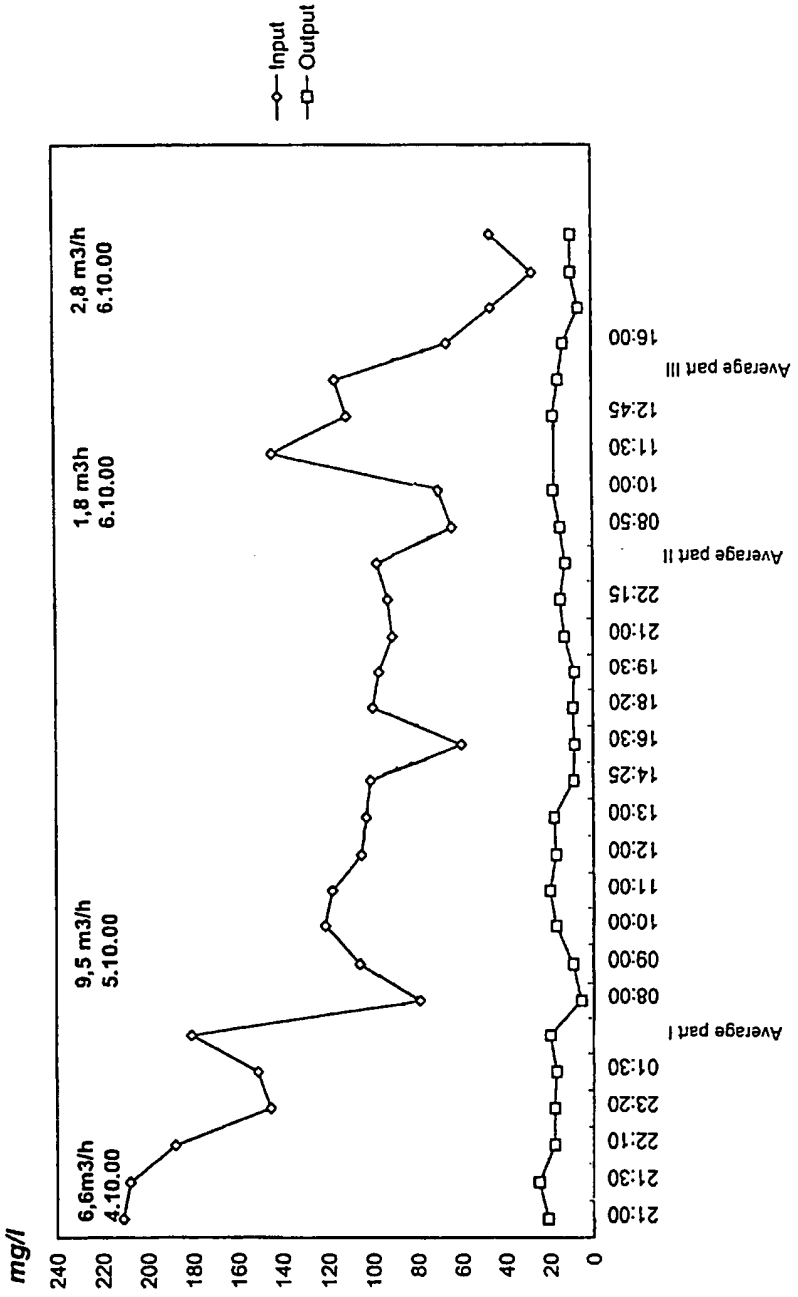


Figure 2.

Figure 3.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EUROPEAN SEARCH REPORT

Application Number
EP 00 61 0118

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16 May 2001	De La Morinerie, B

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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			TECHNICAL FIELDS SEARCHED (Int.Cl.7)

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 61 0118

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82